

FALL PROTECTION SYSTEM AND METHOD

RELATED APPLICATIONS

1 This application is related to and claims the benefit of
2 Provisional U.S. Patent Application Number 60/102,583 entitled
3 FALL PROTECTION SYSTEM AND METHOD, filed September 30, 1998 and
4 incorporated herein by reference.

FIELD OF THE INVENTION

5 This disclosed invention relates generally to fall
6 arresting/prevention devices that provide protection to
7 individuals who are subject to accidental falls when performing
8 construction or the like or when operating elevating construction
9 machinery such as aeriallift boom/baskets and the like.
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BACKGROUND OF THE INVENTION

11 Lanyards are safety straps or the like which are connected
12 between a fixed safety platform and a body harness which is
13 attached to the operator to be protected from a fall. However, in
14 some circumstances the lanyard and body harness may be integrated
15 into a single unit, which for the purposes of this discussion
16 will also be termed a lanyard. Additionally, the body harness
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1 may take a variety of forms, ranging from a simple safety waist-
2 style belt to a full body harness.

3 While there are a variety of lanyard styles, the most common
4 variety consists of a flexible nylon strap which has two locking
5 snap hooks, one attached at each end of the lanyard, although
6 other configurations are possible.

7 One significant safety issue presented when lanyards are
8 used in conjunction with elevating construction machinery such as
9 aerialift booms and the like is the issue of operator compliance.
10 In most circumstances where a construction worker is positioned
11 on a roof or other high structure, it is relatively easy for the
12 worker to realize the immediate need to secure himself to the
13 structure via the use of a lanyard or similar restraining device.
14 The exposed nature of the work environment and the inherent
15 height of the work environment tend to provide a positive
16 reinforcement of the need to take this safety step.

17 However, this type of positive reinforcement is absent in
18 many circumstances where the worker is the operator of an
19 aerialift boom or the like, in which a piece of construction
20 equipment actually transports the worker to an elevated height.
21 In this situation, the aerialift boom operator may be in an
22 aerialift boom basket or the like, and be unaware of the
23 potential for a serious injury from a fall while the aerialift
24 boom is rising or positioned at an elevated height. Furthermore,
25 many aerialift boom baskets are equipped with latching doors

1 which provide ingress and egress from the boom basket. In these
2 situations the operator may be unaware that should the boom door
3 latch fail, a potential for serious injury may exist should a
4 fall occur. In these situations, it is quite common for an
5 aerialift boom operator to forget to secure himself/herself to
6 the aerialift boom/basket via the use of a lanyard and body
7 harness.

8 This situation is exacerbated by the fact that many
9 operators of aerialift booms and the like make many trips up and
10 down in the aerialift boom basket while servicing telephone
11 poles, cable TV hardware, and the like. These scenarios are
12 fraught with situations in which the operator may leave the
13 aerialift boom basket, retrieve tools or the like, return to the
14 aerialift basket, and forget to attach the safety lanyard to
15 his/her body harness before activating the aerialift boom
16 movement controls. It is unfortunate and very sad that there
17 have been many situations in which this scenario has occurred,
18 with the operator subsequently falling from the aerialift boom
19 basket. These accidental falls tend to be quite severe,
20 resulting in broken bones, head and back injuries, as well as
21 documented cases of permanent paralysis.

22 As a result, the U.S. Occupational Safety and Health
23 Administration (OSHA) has promulgated rules mandating fall
24 protection standards in the workplace. These standards generally
25 mandate that no worker be allowed to fall more than six feet and

1 that no worker be allowed to free fall unrestrained more than two
2 feet in a safety belt and four feet in a full body harness. While
3 these standards generally require the use of fall protection
4 systems and methods in conjunction with the use and operation of
5 aerialift booms and the like, they do not dictate any positive
6 system of enforcement regarding the use of these fall protection
7 systems.

8 The alternative to the use of positive enforcement has been
9 the use of human safety monitoring personnel (safety monitors)
10 whose job it is to inspect the workplace and inform workers of
11 potential fall hazards. This approach is obviously only
12 effective in situations where the worker is operating in a group
13 context and would be ineffective for a lone cable TV repairman,
14 for example. The use of written fall protection plans and fall
15 protection training are similarly ineffective in this context.
16 Within the context of aerialift boom/baskets and the like (where
17 the potential for serious injury resulting from an accidental
18 fall is the greatest), the policies and procedures of OSHA seem
19 to have the least potential for affecting an acceptable solution
20 to this serious safety problem.

21 Thus, the existing methodologies do not address the human
22 factor involved in the operation of elevating machinery which can
23 pose potentially deadly fall hazards to their operators. In
24 fact, government regulations and safety training are insufficient
25 to ensure that safety devices are properly used or in fact used

1 at all. Unfortunately, with the rapid expansion of the
2 construction, telecommunications, and cable TV industries, the
3 use of aerialift boom/basket devices has skyrocketed, resulting
4 in a marked increase in accidental falls and subsequent severe
5 injuries to workers in these fields. It is obvious from the
6 record that fall protection training as well as policies and
7 procedures for fall protection are inadequate to solve this
8 problem alone.

9 While the use of lanyards and other fall prevention devices
10 is widespread within the construction industry, there appears to
11 be no art relevant to systems and methods that permit the use of
12 these devices to be mandated or monitored to ensure their proper
13 use. As a result, accidental falls continue to injure and
14 disable thousands of workers per year.

15 Accordingly, what is needed is a system and method of
16 preventing the use of aerialift boom/basket devices and the like
17 unless the operator of such a device is properly secured to the
18 aerialift boom/basket with a body harness and attached lanyard.
19 Such a system should also minimize the operational impact on the
20 use of existing lanyard devices by not requiring the
21 operator/worker to perform extra safety related functions to
22 affect mandatory use of the lanyard.

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1 FIG. 1 illustrates a schematic of a prior art aerialift
2 boom/basket fall protection system utilizing a lanyard and body
3 harness;

4 FIG. 2 illustrates a schematic of one embodiment of the
5 present invention in which a lanyard safety interlock prevents
6 aerialift boom movement unless the operator is properly secured
7 via a safety lanyard;

8 FIG. 3 illustrates a conventional aerialift boom/basket
9 applications and the connection of the elevated machine operator
10 to the aerialift boom/basket;

11 FIG. 4 illustrates one embodiment of the present invention
12 utilizing a looped lanyard implementation;

13 FIGS. 5A and 5B illustrate a schematic of an exemplary
14 embodiment of the present invention in which the securing D-rings
15 may be electrically isolated from the ground and circuitry of the
16 aerialift boom, thus increasing the overall operational safety of
17 the lanyard interlock system;

18 FIG. 6 illustrates another embodiment of the present
19 invention using a dual lanyard implementation;

20 FIG. 7 illustrates a schematic of an exemplary embodiment
21 of the present invention in which a diode or other current
22 steering element in conjunction with bi-directional current
23 generators is used to prevent circumvention of the lanyard safety
24 interlock system;

1 FIG. 8 illustrates yet another embodiment of the present
2 invention using a magnetic sensor;

3 FIG. 9 illustrates an additional embodiment of the present
4 invention using a Y-style lanyard with a magnetic sensor;

5 FIG. 10 illustrates another embodiment of the present
6 invention using an optical feedback mechanism;

7 FIG. 11 illustrates another embodiment of the present
8 invention using a radio frequency (RF) transmitter as the lanyard
9 safety interlock means;

10 FIG. 12 illustrates an exemplary block diagram of a radio
11 frequency (RF) lanyard interlock embodiment of the present
12 invention using a conductive lanyard;

13 FIG. 13A illustrates an exemplary block diagram of a radio
14 frequency (RF) lanyard interlock embodiment of the present
15 invention using a capacitive lanyard;

16 FIG. 13B illustrates an exemplary schematic of an RF
17 transmitter which may be suitable for use in a radio frequency
18 (RF) lanyard interlock embodiment of the present invention;

19 FIG. 14 illustrates an exemplary schematic of an RF receiver
20 which may be suitable for use in a radio frequency (RF) lanyard
21 interlock embodiment of the present invention;

22 FIG. 15 illustrates an exemplary block diagram showing how
23 autoidentification information may be transmitted over the safety
24 lanyard in an RF lanyard interlock invention embodiment;

1 FIGS. 16A, 16B and 16C illustrate one embodiment of a
2 lanyard which may be utilized with the radio frequency (RF)
3 interlock scheme illustrated in FIG. 11 in which the lanyard is
4 configured as a weak capacitor to facilitate the transmission of
5 RF energy;

6 FIGS. 17A and 17B illustrate one embodiment of a harness D-
7 ring which may be used to provide an activation interlock for the
8 RF transmitter interlock illustrated in FIG. 11.

9 FIG. 18 illustrates how the harness D-rings may be utilized
10 as a power switching means to conserve battery power in an RF
11 lanyard interlock invention embodiment;

12 FIG. 19 illustrates an embodiment of the present invention
13 used in conjunction with a speech and/or audible warning system
14 capable of providing and logging operator warning messages in the
15 event of a safety protocol violation involving proper safety
16 lanyard use;

17 FIG. 20 is a flow chart showing the steps of a method of
18 providing operator protection according to the teachings of the
19 present invention.

20 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

21 The following detailed description will describe the present
22 invention in relation to elevating machinery in terms of the
23 common context of aerialift boom/basket devices. However, the
24 present invention should not be constrained or limited to this

1 particular application as the teachings are equally applicable to
2 any type of machinery or device where it is important to ensure
3 that the operator of such is positively connected to such device.
4 In addition, the disclosed invention can be integrated with other
5 aerialift warning systems, such as the system disclosed in
6 commonly-owned, co-pending U.S. Patent Application Ser. No.
7 09/347,471, entitled Aerial Lift Warning System and Method, which
8 is incorporated herein by reference.

9 Turning now to the Figures and, in particular, FIG. 1, in a
10 conventional fall protection system (100) targeted towards an
11 aerialift boom/basket, the operator (101) is in an aerialift
12 basket (102) supported by an aerialift boom (103). As a part of
13 either the aerialift basket (102), aerialift boom (103), or an
14 extension thereof (104), a lanyard (106) is connected between a
15 body harness (107) and some securing point on the aerialift
16 (105). Within this conventional system context, system power
17 (110) is switched through one or more boom movement controls
18 (111) to trigger a boom actuator (112) which energizes a boom
19 motor (113) that moves the aerialift boom/basket (103, 102).

20 The present invention augments this conventional prior art
21 system as illustrated in FIG. 2. Here, the boom actuator (212)
22 to boom motor (213) control path is broken by a controllable
23 switch (220) which is symbolically illustrated as a relay but may
24 be any device capable of switching electrical current. The
25 switch (220) is controlled by a lanyard interlock control (221)

1 which prevents the boom actuator (212) from activating the boom
2 motor (213) unless the lanyard connection detector (222)
3 indicates that the lanyard (206) is properly attached between the
4 operator body harness (207) and some securing point (205) on the
5 aerialift boom/basket (202, 203, 204).

6 It should be noted that the system illustrated in FIG. 2
7 implies a normally energized boom actuator (212) to boom motor
8 (213) path. The present invention is not limited to this context
9 and can be easily modified such that the lanyard safety interlock
10 control (221) does not energize the switch (220) unless a
11 positive indication of the lanyard connection detector (222) is
12 indicated. This alternative configuration prevents boom motor
13 (213) and subsequent aerialift basket (202) movement in the event
14 of a system failure within the lanyard interlock control (221).

15 The lanyard interlock control (221) design is in part
16 determined by the method by which the lanyard connection detector
17 (222) is implemented. The remainder of the detailed description
18 will concern alternative embodiments of the lanyard connection
19 detector 222 and methods of detecting whether an operator (201)
20 has properly attached the lanyard (206) from the body harness
21 (207) to the aerialift boom/basket structure (205, 204, 203,
22 202).

23 The following exemplary embodiments will present an
24 application context of providing fall protection in an aerialift
25 boom system as illustrated in FIG. 3. A conventional aerialift

1 boom application has a truck (301) or other support on which an
2 aerialift boom (302) supports an aerialift basket (303) in which
3 an operator (304) works. This aerialift operator (304) is
4 typically restrained to the aerialift basket (303) via a body
5 harness (305) equipped with a harness D-ring (306) which connects
6 a safety lanyard (307) having fasteners, such as snap hooks (310,
7 312), which connect the harness D-ring (306) to an attachment
8 point, such as support D-ring (308). In addition to the threat
9 of falling over the top edge of the aerialift basket (303), there
10 exists a fall hazard presented by door (310) of the aerialift
11 basket.

12 Within the context of the exemplary embodiments the support
13 D-ring (308) has been stylized to be located on the aerialift
14 basket (303), however in many preferred embodiments support D-
15 ring(s) (308) may be attached directly or indirectly to the
16 aerialift boom (302) via a mounting bracket or similar structure.

17 One embodiment of the lanyard connection detector (222)
18 (Fig. 2) is illustrated in FIG. 4. Here, the conventional one-
19 piece lanyard (307) of FIG. 3 having two snap hooks (310, 312)
20 connected via a nylon strap or the like is replaced with a looped
21 lanyard, which differs from a one-piece lanyard in the following
22 manner:

- 23 1. The lanyard (405) is increased in length to approximately
24 double its normal length, and encircles the harness D-ring
25 (407) which is secured to the body harness (408).

- 1 2. The lanyard loop encircling the harness D-ring is closed and
2 secured with a fastening means (406) to ensure that the
3 effective length of the safety lanyard is approximately half
4 of its full length, or 'the proper length (as required by
5 OSHA).
- 6 3. First and second securing attachment points, such as D-rings
7 and their associated mounting plates (403, 404), are used on
8 the aerialift boom/basket rather than a single securing D-
9 ring.
- 10 4. The securing D-rings and mounting plates (403, 404) attached
11 to the aerialift boom/basket are electrically separated to
12 provide a means of completing an electrical circuit when the
13 fasteners, such as snap rings (401, 402), of the lanyard are
14 connected at each of the securing D-rings.
- 15 5. The lanyard strap (405) is treated with a conductive agent,
16 such as zinc oxide or the like or is impregnated with
17 conductive strands to permit the conductivity of the lanyard
18 to rise to a level which may permit its overall resistivity
19 to be measured.
- 20 6. A conductivity sensor is incorporated between each of the
21 securing D-rings to permit detection of the presence of the
22 semi-conductive lanyard intermediate each of the securing D-
23 rings.
- 24 The key to this embodiment example is the transformation of
25 the safety lanyard from essentially an 'insulator' to a

1 'conductor'. However, within the context of this embodiment the
2 term 'conductor' must be given broad scope. For instance, it may
3 be possible to treat the lanyard with a conductive solution and
4 impregnate the nylon weave with zinc oxide or some other material
5 which would provide for a nominal conductance in the range of
6 hundreds of millions or even billions of ohms and still be able
7 to detect this resistance between the securing D-rings on the
8 aerialift boom/basket. In this application and throughout this
9 document, the use of zinc oxide should be equated with any
10 conventional method of providing marginal conductivity. Many of
11 these techniques are well known in the art of preventing
12 electrostatic discharge (ESD) in the electronics industry, and
13 range from conductive clothing materials to conductivity agents
14 which are used to dope clothing and work materials to increase
15 their conductivity above the level of a conventional insulator.

16 Additionally, while the system illustrated may operate best
17 in terms of a DC resistance measurement, it may also be possible
18 to determine the proper connection of the safety lanyard clips by
19 use of an AC capacitance measurement. This approach may be of
20 use in instances where it is desirable to maintain a high degree
21 of DC isolation between the body harness and the aerialift
22 support D-rings, as may be the case in some power line
23 maintenance machinery. The technique of converting the safety
24 lanyard strap from a conductive to a reactive sensor will be
25 discussed more fully below.

1 It should be noted that in many circumstances the concern
2 over a direct conductive path between the securing D-rings and
3 the electrical ground of the aerialift boom/basket may be
4 addressed by configurations similar to that illustrated in FIGS.
5 5A and 5B. Here, the conductive DC interlock is illustrated by
6 the schematic (500) generally, wherein a battery (501) or other
7 power source is used to supply current through the securing D-
8 rings (503, 504) and the conductive lanyard to supply operating
9 current to the boom movement enable interlock (502). In this
10 scenario, there is a DC path between the securing D-rings (503,
11 504) and the system ground (506) which can present a safety
12 threat in some operating environments.

13 In 5B, the isolated AC interlock illustrated by the
14 schematic (510) utilizes an AC signal source (511) which is
15 isolated by transformers (517, 518) from the securing D-rings
16 (513, 514) and the conductive lanyard (515). Once the electrical
17 connection between the securing D-rings (513, 514) and the
18 conductive lanyard (515) is made, AC current will flow in the
19 secondary of transformer (518) and be used by AC detector (519)
20 to trigger the boom movement enable interlock (512).

21 The advantages of this embodiment include a relatively
22 robust and durable lanyard which has minimal modification
23 requirements over existing lanyard systems. The installation of
24 the second securing D-ring is a minor extension of current
25 lanyard securing methods.

1 One disadvantage of this disclosed embodiment is that it
2 requires TWO securing operations each time the operator secures
3 the safety lanyard to the aerialift boom/basket. While many
4 safety administrators may view this as an advantage in that the
5 operator is now doubly secured to the aerialift, from an operator
6 point of view the requirement that two snap hooks be attached to
7 the aerialift presents a significant burden in everyday use,
8 since the securing operation in general may happen dozens of
9 times during a given day or during a series of maintenance
10 functions.

1 Yet another potential disadvantage of this approach is the
2 issue of the potential for defeating the lanyard interlock.
3 Using just the conductivity between the securing D-rings as the
4 method of detecting the presence of a properly attached lanyard
5 can be defeated by simply tying a wire between the securing D-
6 rings. This in essence would defeat the interlock by falsely
7 indicating to the resistance detection system previously
8 discussed that the lanyard was properly attached when in fact it
9 is not. This potential for safety interlock circumvention is
10 addressed by other embodiments of the present invention which are
11 addressed in more detail herein.

12 Thus, this embodiment prevents aerialift boom operation in
13 the absence of two secured safety clips which are part of an
14 integrated lanyard safety system.

1 Another embodiment of the lanyard connection detector (222)
2 (Fig. 2) is illustrated in FIG. 6. Here, the conventional one-
3 piece lanyard of FIG. 3 having two snap hooks connected via a
4 nylon strap or the like is augmented in the following manner:

5 1. Rather than a single lanyard as in the previous embodiment,
6 this embodiment utilizes first and second lanyards (605,
7 606) to connect the harness D-rings (609, 610) to the body
8 harness (611).

9 2. Two securing D-rings and their associated mounting plates
10 (603, 604) are used on the aerialift boom/basket rather than
11 a single securing D-ring.

12 3. The securing D-rings and mounting plates (603, 604) attached
13 to the aerialift boom/basket are electrically separated to
14 provide a means of completing an electrical circuit when the
15 snap rings of the lanyard are connected at each of the
16 securing D-rings.

17 4. The lanyard straps (605, 606) are treated with a conductive
18 agent, such as zinc oxide or the like or is impregnated with
19 conductive strands to permit the conductivity of the lanyard
20 to rise to a level which may permit its overall resistivity
21 to be measured.

22 5. A conductivity sensor is incorporated between each of the
23 securing D-rings to permit detection of the presence of the
24 semi-conductive lanyard between each of the securing D-
25 rings.

1 6. At least one operator attachment point, such as harness D-
2 rings (609, 610), are fitted on the body harness to permit
3 attachment of the lanyards from the securing D-rings on the
4 aerialift boom/basket via the use of snap hooks (607, 608).

5 The major difference between this embodiment and the
6 embodiment of Fig. 4 is the fact that conventional, commercially
7 available, safety lanyards may be used in this system after they
8 are properly treated to become at a minimum marginally conductive
9 to electric current. This results in a potential for overall
10 reduction in tooling costs over the previous embodiment.

11 The D-rings on the body harness may be constructed in a wide
12 variety of ways. In some preferred embodiments, there are more
13 than one D-ring on the body harness, permitting separate
14 connection of the conductive lanyards to each separate D-ring.
15 This approach has the advantage of permitting a variation of the
16 looped lanyard conductance methodology described previously.

17 In the looped lanyard methodology, the resistance between
18 the lanyard securing D-rings is measured to determine in a DC or
19 AC sense whether the lanyard is properly attached to the body
20 harness. The disadvantage of this approach is that the safety
21 interlock can be defeated if a simple electrical connection is
22 made between the securing D-rings. To prevent this situation, if
23 two D-rings are placed in an electrically isolated fashion on the
24 body harness, a diode or similar 1-way conducting device can be
25 placed between these D-rings. This simple addition as

1 illustrated in FIG. 7 permits direct current to flow in one
2 direction only through the safety lanyards. This condition can
3 be detected by appropriate electronics which drive current at the
4 securing D-rings, thus permitting the detection of a properly
5 attached safety lanyard.

6 Referring to FIG. 7, this embodiment of the present
7 invention operates by the addition of diode (704) or other device
8 to permit current flow in only one direction in the system.
9 Current enters the lanyard through securing D-ring (701) and is
10 transmitted via conductive lanyard (702) to harness D-ring (703)
11 where it is either conducted or blocked by diode (704) based on
12 the sense of the attempted current flow. Harness D-rings (703,
13 706) and diode (704) are typically mounted on a single mechanical
14 structure on body harness (705), but many other implementations
15 using this general teaching are possible. Current flowing out of
16 diode (704) is conducted through harness D-ring (706) through
17 conductive lanyard (707) to securing D-ring (708). This current
18 then flows through a current sensor and back to either one of
19 directional current sources (710, 711).

20 Note that switch (712) determines which current source (710,
21 711) is selected for testing the presence of proper lanyard
22 attachment. While DC current sources are illustrated here, the
23 result could just as easily be accomplished using an AC source.
24 In either circumstance, the current sensor (709) will detect
25 current flow in one switch (712) position and no current flow in

1 the other switch position. If this condition is met, the system
2 can be assured that the operator has properly attached both
3 safety lanyards between the securing D-rings (701, 708) and the
4 corresponding harness D-rings (703, 706).

5 Most importantly, any attempt by the operator to defeat the
6 safety interlock by placing a conductive lanyard (702, 707)
7 across the securing D-rings (701, 708) will permit current to
8 flow in BOTH positions of the switch (712), and thus this will be
9 an indication that the safety lanyards are NOT properly attached.
10 Note that the current sensor (709) can be replaced by a voltage
11 sensor attached to securing D-rings (701, 708), which will detect
12 the open circuit voltage of current sources (710, 711) when diode
13 (704) is not conducting, and a conventional diode drop (typically
14 0.6 volts) when diode (704) is conducting. Thus, when using a
15 voltage sensor rather than a current sensor, a differential in
16 measured voltage must be observed when the switch (712) is in
17 different positions for the system to properly detect that the
18 safety lanyards are properly attached.

19 Yet another approach to detecting whether the lanyards are
20 properly attached to the harness D-rings is the use of what in
21 the electronics industry is termed a '1-wire autoidentification
22 device' such as that made by Dallas Semiconductor Corporation of
23 Dallas, Texas and marketed as the 'TOUCH MEMORY' and 'iButton'
24 product lines. These devices are essentially semiconductor
25 memories which are accessed using two electrical connections: (1)

1 power/data and (2) ground. These devices are available in TO-92
2 form factors as well as conventional lithium battery canister
3 form factors and as such are amenable to use in this application.
4 Since these are in fact memory devices, they may be accessed to
5 obtain serial numbers and other information regarding which
6 operator used which aerialift. Additionally, if desired it is
7 possible using these devices to determine how many times the
8 aerialift boom operator failed to attach his/her safety lanyard
9 prior to operating the aerialift boom/basket. This feature can
10 be useful in safety monitoring and compliance control by
11 government agencies such as OSHA as well as providing indications
12 to safety management as to which aerialift operators require
13 additional safety training.

14 The approach given in this exemplary embodiment has the
15 advantage of providing twice the safety support for the operator
16 in the event of a potential fall, as two safety lanyards are
17 always attached to the operator's body harness and the aerialift
18 boom/basket.

19 Most notable in this implementation is the potential for
20 eliminating the safety interlock circumvention mechanism present
21 in the looped lanyard configuration. By utilization of a diode
22 or other differential current or autoidentification semiconductor
23 device, it is possible to eliminate the possibility that the
24 operator has shorted the securing D-rings together in an attempt
25 to defeat the safety system. This is a highly desirable result

1 given that most aerialift operators are unsupervised in the field
2 and as such there is very little positive monitoring which can be
3 performed once the aerialift operator is on the job and using the
4 aerialift.

5 However, as stated previously, the use of multiple lanyard
6 connections creates an operational overhead that is not desirable
7 in most aerialift applications. Nonetheless, in situations where
8 safety is paramount, this embodiment has merit in ensuring that
9 should one lanyard fail, that the operator would still be
10 protected by virtue of the remaining safety lanyard. Therefore,
11 the dual lanyard approach illustrated by this embodiment permits
12 an increase in operator safety margin while simultaneously
13 eliminating a potential safety threat posed by operators who
14 attempt to circumvent the lanyard safety interlock system.

15 Another embodiment of the lanyard connection detector (222)
16 (Fig. 2) is illustrated in FIG. 8. Here, the conventional one-
17 piece lanyard of FIG. 3 having two snap hooks connected via a
18 nylon strap or the like is augmented in the following manner:

- 19 1. A multi-wire cable (806) is attached to the lanyard (804)
20 and connected (805) to the aerialift boom at the support D-
21 ring side of the lanyard.
- 22 2. The additional cable (806) runs the length of the safety
23 lanyard (804) and terminates at a magnetic sensor (807).

- 1 3. The snap hook (808) which connects to the harness D-ring
2 (809) is constructed of a metal which is capable of being
3 temporarily magnetized with a permanent magnet.
- 4 4. The harness D-ring (809) is constructed of a metal which can
5 be temporarily magnetized via the use of a permanent magnet.
- 6 5. The harness D-ring (809) is fastened to the body harness via
7 a metal plate which supports magnetism.
- 8 6. One or more permanent magnets (810) are attached to the
9 metal plate, making the harness D-ring (809) permanently
10 magnetic.

11 In this embodiment, the sensor, which determines whether the
12 safety lanyard is properly attached is magnetic. When the
13 operator attaches the snap hook (808) at the end of the safety
14 lanyard to the harness D-ring (809), the magnetic sensor (807) at
15 the end of the safety lanyard will detect that the lanyard snap
16 hook (808) has experienced an increase in magnetic field. This
17 increase in magnetic field is the result of an indirect magnetic
18 connection between the permanent magnets (810) in the body
19 harness which magnetize the harness D-ring (809) and subsequently
20 the snap hook (808) at the end of the safety lanyard (804).

21 As one skilled in the art will be aware, there are a wide
22 variety of devices and methods of detecting the presence of a
23 magnetic field near the end of the safety lanyard. Two potential
24 candidates for this application include the use of a magnetic
25 reed relay switch as well as the use of Hall effect sensor.

1 Magnetic reed relay switches are widely used in the home
2 burglar alarm industry and the like and essentially are switches
3 which, when exposed to a magnetic field close, making an
4 electrical switch contact. These types of switches are well
5 known in the art and in general require a relatively large
6 magnetic field to enable their closure. A larger magnetic field
7 requirement requires tighter coupling between the safety lanyard
8 snap hook and the harness D-ring, meaning more assurance of a
9 properly connected lanyard.

10 Hall effect sensors, such as manufactured by Allegro
11 MicroSystems, Inc. of Worcester, Massachusetts and Melexis
12 Incorporated of Webster, Massachusetts, come in a wide variety of
13 configurations, most of which would be suitable for this
14 application. The advantage in using a Hall effect sensor is in
15 general greater sensitivity, smaller size, and more rugged
16 construction as compared with convention magnetic reed relay
17 switches. Additionally, for this application it is envisioned
18 that the wide variety of linear Hall effect sensors would be
19 particularly useful, as these devices would permit the threshold
20 of mating contact to be adjusted as desired for optimal system
21 safety and interlock effectiveness.

22 The advantages of this embodiment as compared to the looped
23 lanyard and dual lanyard approaches is that only a single lanyard
24 snap hook need be connected to the harness D-ring to affect
25 proper lanyard safety and activate the lanyard safety interlock.

1 The disadvantages of this particular embodiment generally
2 fall into two categories. First, the use of any electrical
3 wiring or connector along in conjunction with the lanyard poses a
4 reliability problem. Lanyards are in general subject to rough
5 treatment during the course of daily use. It is possible that
6 any wiring attached to the lanyard would break, rendering the
7 safety interlock system inoperable. Second, the addition of
8 magnets to the safety harness D-ring structure increases the
9 weight of the safety harness and contributes to general operator
10 fatigue.

11 Thus, the magnetic interlock embodiment of the present
12 invention provides a significant advantage over the prior art by
13 permitting the aerialift boom movement to be inhibited unless a
14 single lanyard connection is found to be properly secured between
15 the operator and the aerialift boom. While the deficiency of the
16 system is primarily one of proper materials selection, the system
17 shown in FIG. 8 permits this embodiment to be implemented using
18 commercially available parts with no major modifications to
19 existing lanyard and body harness hardware.

20 Another embodiment of the lanyard connection detector (222)
21 (FIG. 2) is illustrated in FIG. 9. Here, the conventional one-
22 piece lanyard of FIG. 2 having two snap hooks connected via a
23 nylon strap or the like is augmented as illustrated in FIG. 9 in
24 the following manner:

1 1. The modifications are substantially identical to the
2 magnetic interlock exemplary embodiment discussed above,
3 with the exception that two support D-rings (903, 904) are
4 required on the aerialift boom.

5 2. The lanyard belt (907, 908) is constructed as a conductive
6 Y-style lanyard (900), such that two snap hooks (905, 906)
7 are connected to the aerialift boom/basket support D-rings
8 (903, 904) and these belts are configured to support the
9 conduction of two separate conductors to the magnetic sensor
10 (913) described in the magnetic interlock embodiment
11 described above.

12 The major distinction between this embodiment and that of
13 the magnetic interlock embodiment described above is in a
14 refinement of the lanyard so that it supports the conduction of
15 two currents to the magnetic sensor instead of requiring the use
16 of separate wires for this function. By integrating the wiring
17 function into the lanyard, this embodiment greatly extends the
18 lifespan of the lanyard, which is typically subjected to rough
19 treatment and abuse in the field.

20 The Y-style lanyard (900) as constructed in FIG. 9 may
21 actually comprise TWO separate lanyards (907, 908) that have been
22 sewn together along a portion of their length (920). On the
23 outside of each of these lanyards prior to the sewing process a
24 conductive material such as tape, foil, or the like has been
25 placed. Once the lanyards are sewn together the two conductors

1 can be brought out to the magnetic sensor and used as wires to
2 conduct information to and from the magnetic sensor.

3 Another approach to this problem is to have conductive
4 material woven into each lanyard prior to its being attached to
5 its mate via sewing. These inner conductors would be protected
6 from the environment and can then be brought out to the support
7 snap hooks and the magnetic sensor as desired.

8 One advantage to this approach is the elimination of
9 separate wires in the magnetic interlock embodiment, which
10 results in a much greater system reliability, since lanyards are
11 often subject to harsh treatment.

12 Thus, the Y-style conductive lanyard (900) appears to solve
13 most of the major operational problems of the magnetic interlock
14 embodiment as well as providing a single point of aerialift
15 boom/basket connection between the operator and the safety
16 lanyard. This is a significant leap in protection because for
17 the first time a system and method for integrating a lanyard
18 interlock with a single manual hookup operation has been
19 demonstrated. This permits current aerialift operators to
20 function just as they do currently, with the added provision that
21 any failure to properly attach their safety lanyard will disable
22 movement of the aerialift boom/basket.

23 Another embodiment of implementing the lanyard connection
24 detector (222) (FIG. 2) is illustrated in FIG. 10. Here, the
25 conventional one-piece lanyard (307) of FIG. 3 having two snap

hooks (310, 312) connected via a nylon strap or the like is augmented as illustrated in FIG. 10 in the following manner:

1. A multi-wire cable (1005) is attached to the lanyard (1006) and connected to the aerialift boom at the support D-ring side of the lanyard (1004).

2. The multi-wire cable (1005) runs the length of the safety lanyard and terminates at an optical transceiver (1007), including an optical transmitter and optical receiver sensor near the snap hook (1008).

3. The harness D-ring (1009) is surrounded with a reflective material (1010) which reflects light as emitted by the optical transmitter, such that when the optical transmitter is restrained near the harness D-ring (1009), the optical transceiver (1007) receives backscatter radiation that indicates that the lanyard snap hook (1008) is properly connected to the harness D-ring (1009). In this embodiment of the invention, as with others, the D-ring (1009) may in itself include a variety of functionally equivalent embodiments.

This embodiment makes use of an optical transmitter/receiver (1007) to scatter light off a reflective surface (1010) near or surrounding the harness D-ring (1009) and thus indicate the local presence of the end of the lanyard to the body harness. Since the present invention envisions inspection of this locality condition throughout any movement of the aerialift boom, the test

1 of proper optical feedback from the body harness will ensure that
2 the operator is properly secured with a lanyard prior to moving
3 the aerialift boom/basket.

4 In the alternative, an optical/mechanical sensor combination
5 may be used. Rather than detect the backscatter of optical
6 radiation from the body harness, this approach uses a switch
7 designed to detect optical blockage. Such switches have an
8 optical transmitter and an optical receiver in close proximity
9 with an air gap between the two. As an object comes between the
10 transmitter and the receiver, this is electrically detected by
11 the transmitter/receiver pair. Such devices are widely available
12 as 'photo micro sensors' from companies such as Sunx of West Des
13 Moines, Iowa.

14 This embodiment has the advantage of being relatively simple
15 to implement. No major changes are required in the construction
16 of conventional body harness, with the exception of the addition
17 of reflective tape or the like surrounding the harness D-ring.
18 Optical transmitter/receiver combinations are widely available,
19 and are available in both the visible and invisible spectrum.
20 Additionally, this embodiment has the same advantage as that of
21 the magnetic interlock: a single point of hookup between the
22 lanyard and the body harness.

23 However, this embodiment, as with the magnetic interlock
24 system, requires an additional cable which must be attached to
25 the lanyard.

1 Another drawback of this embodiment involves operator
2 circumvention of the interlock mechanism. Both optical/
3 reflective and optical/mechanical embodiments discusses are
4 susceptible to defeat by operators who may be determined to
5 override their inherent safety features.

6 Nonetheless, a relatively simple method of implementing the
7 present invention has been shown which utilizes optical and/or
8 optical/mechanical transmitter/receiver technologies to affect
9 the required lanyard interlock detector.

10 Another method of implementing the lanyard connection
11 detector (222) (FIG. 2) is illustrated in FIG. 11. Here, the
12 conventional one-piece lanyard (307) of FIG. 3 having two snap
13 hooks (310, 312) connected via a nylon strap or the like is
14 augmented as illustrated in FIG. 11 in the following manner:

- 15 1. The lanyard (1104) is coated/impregnated or otherwise
16 treated with a marginally conductive material to make the
17 lanyard marginally conductive, and therefore susceptible to
18 the transmission of radio frequency (RF) energy.
- 19 2. A radio-frequency (RF) transmitter (1107) is electrically
20 connected to the harness D-ring (1106) on the body harness
21 (1108).
- 22 3. A radio frequency (RF) receiver (1109) is attached to the
23 support D-ring (1102) on the aerialift boom/basket near the
24 support bracket (1101).

1 4. The RF transmitter (1107) is designed to have no appreciable
2 antenna, and therefore will be a very poor radiator of RF
3 energy.

4 5. The RF transmitter (1107) is specifically designed (contrary
5 to popular practice) to have a very low signal level present
6 at its transmitter output, resulting in very low radiation
7 levels at the body harness.

8 6. The RF receiver (1109) is designed to have no appreciable
9 antenna, and therefore will be a very poor receiver of
10 radiated RF energy.

11 7. The proper connection of the conductive lanyard (1104) from
12 the aerialift boom/basket support D-ring (1102) to the
13 harness D-ring (1106) permits sufficient RF energy to be
14 directly conducted from the RF transmitter (1107) to the RF
15 receiver (1109) to trigger an interlock threshold and permit
16 the operator to move the aerialift boom/basket.

17 A basic block diagram illustrating a RF lanyard interlock
18 embodiment is illustrated in FIG. 12. Here a data encoder (1201)
19 generates a data stream which is used to modulate a RF
20 transmitter (1202), which is specifically designed to have weak
21 transmission characteristics. This transmitter (1202) is
22 electrically connected to the harness D-ring (1203) which serves
23 as a poor antenna for radiation purposes.

24 However, a conductive lanyard (1204) is used to conduct RF
25 energy from the RF transmitter (1202) from the harness D-ring

1 (1203) to the securing D-ring (1205). This RF energy is then DC
2 blocked using an optional capacitor (1206) and then fed into an
3 RF receiver which demodulates the data modulated in the RF
4 carrier wave. This data is then decoded (1208) and checked by a
5 pattern detector (1209) for a predetermined data pattern to
6 decide if the boom motor enable (1210) should be activated. If
7 the proper data pattern generated by the data encoder (1201) is
8 matched, the boom motor (1211) is allowed to operate.

9 The key to this system is that the RF receiver (1207) and RF
10 transmitter (1202) are gain degenerated by means of making their
11 effective antenna structures very inefficient. Thus, RF energy
12 will have very poor radiation characteristics from the
13 transmitter and very poor gain characteristics at the receiver.
14 However, by use of a conductive lanyard (1204), this energy can
15 be efficiently transmitted between the harness D-ring (1203) and
16 the securing D-ring (1205). Only when the connection of the
17 conductive lanyard is complete will the signal strength of the RF
18 transmitter generate sufficient RF energy at the RF receiver
19 (1207) to trigger the boom motor. Note that the lanyard (1204)
20 in this application need not be conductive in a DC sense of the
21 word, but may be capacitively reactive as illustrated in FIG. 13.
22 Here the lanyard (1304) is of the capacitive variety, which will
23 be discussed in more detail with respect to FIGS. 16A, 16B and
24 16C below. With this type of lanyard, the capacitance of the

1 lanyard is increased while maintaining its DC isolation
2 characteristics.

3 The RF transmitter (1302) can take a wide variety of forms.
4 However, one or more embodiments may make use of SAW (surface
5 acoustic wave) stabilize (1303), a typical embodiment of which is
6 illustrated in FIG. 13B. SAW devices (1404) essentially perform
7 the function of high-Q filters and are available from a wide
8 variety of sources such as RF Monolithics (RFM) of Dallas, Texas.

9 The implementation of the RF receiver (1307) can be in a
10 wide variety of forms, but several preferred embodiments make use
11 of Micrel Semiconductor (San Jose, California) QUICKRADIO(tm)
12 brand RF receivers. As illustrated in FIG. 14, a typical
13 embodiment of the RF receiver using this technology has the
14 advantage of being a single-chip solution which can operate in
15 the 300-900 MHz range. This makes use of SAW (surface acoustic
16 wave) stabilized RF transmitters practical. The exemplary RF
17 receiver embodiment of FIG. 14 takes RF energy from the lanyard
18 (1401) to the support D-ring (1402) and filters it with an
19 inductor/capacitor tank (C1/L1). This signal is then processed
20 by a RF receiver integrated circuit (U1) which locks onto the RF
21 carrier signal using a ceramic resonator (X1). Direct digital
22 serial data output (DATAOUT) is provided by this embodiment which
23 may be used as input into a data decoder and pattern detector as
24 illustrated in FIG. 12 and FIG. 13A.

1 One significant advantage of this embodiment is the
2 potential for uniquely identifying each body harness and/or
3 operator via the use of an autoidentification memory device such
4 as the iButton or other memory device such as sold by Dallas
5 Semiconductor and mentioned previously. As illustrated in FIG.
6 15, an autoidentification memory device (1501) may be
7 interrogated by a memory interface (1502) which is driven by a
8 state machine (1503). The output of the memory interface (1502)
9 may be used to generate data (1504) which uniquely identifies the
10 body harness (and thus the operator) which is attempting to
11 operate the aerialift boom. This tracking information can be
12 used to determine which operators attempted to operate the
13 aerialift boom without having an attached safety lanyard. This
14 information can be subsequently used in the context of safety
15 training or safety monitoring. This information could also be
16 used in conjunction with permissive operator interlocks, which
17 would be configured to only allow operators who are qualified to
18 operate certain types of equipment to use such equipment. For
19 example, an operator who is only trained and thus qualified to
20 use a boom lift having a two story height capacity could be
21 prevented from operating more capable boom lift equipment, such
22 as a boom lift having a five story height capacity.

23 One significant aspect of this embodiment is the fact that
24 from the operator's perspective, there is no change in the normal
25 operation of the system. In fact, the implementation of this

1 system makes very little change to existing hardware, with the
2 exception of the RF transmitter which must be placed on every
3 body harness. The remaining components can easily fit within the
4 context of existing aerialift hardware.

5 The main disadvantage to this system is the requirement that
6 the aerialift operator carry a RF transmitter on his/her body
7 harness. This requirement necessitates the use of a battery to
8 power the RF transmitter and therefore the cost of batteries is
9 an ongoing maintenance issue. This cost is mitigate by two
10 factors. First, the RF transmitter is operated at a very low
11 current level to ensure that only a proper attachment of the
12 lanyard between the RF transmitter and the RF receiver will
13 trigger the interlock mechanism. Secondly, as described
14 subsequently in FIGS. 17A, 17B and 18, it is possible to redesign
15 the harness D-ring to integrate a switch mechanism which only
16 enables the RF transmitter when the lanyard snap hook is engaged
17 with the harness D-ring. Thus, this system limits the overall
18 current consumption to just the actual time that the aerialift
19 operator is secured with the lanyard to the aerialift
20 boom/basket.

21 Nevertheless, this embodiment provides a robust lanyard
22 interlock detection system which uses very low power RF
23 transmitters and RF receivers to implement a positive compliance
24 lanyard interlock.

Yet another embodiment of the lanyard connection detector (222) (FIG. 2) is illustrated in FIGS. 16A, 16B and 16C. Here, the conventional one-piece lanyard (307) of FIG. 3 having two snap hooks (310, 312) connected via a nylon strap or the like is augmented as illustrated in FIGS. 16A, 16B and 16C in the following manner:

1. The configuration of the RF interlock of FIG. 11 is used, with only a modification to the safety lanyard.
2. The safety lanyard (1601) is constructed with first and second conductive strips (1614, 1611) on either side of the lanyard such that the strips form a parallel plate capacitor, with a non-conductive lanyard webbing material (1613) acting as the dielectric between the capacitor 'plates' which are formed by the opposing conductive strips.
3. Conductive fasteners, such as snap hooks (1602, 1603), at either end of the lanyard are electrically connected to the opposing conductive strips within the lanyard, such that each of the two snap hooks (1609, 1615) represents a connection to each of the two corresponding 'plates' of the lanyard capacitor (1612, 1617).
4. A variety of methods of interdigitating the dielectric and conductive portions of the lanyard capacitor are possible, by placing the electrical conductors on the outside of the lanyard and wrapping them around the lanyard snap hook (1609) or by placing the electrical conductors in the inside

1 of the lanyard and wrapping them around the lanyard snap
2 hook (1615).

3 5. Depending on the application, the lanyard strap may be
4 double-wrapped (1605) around the snap hook (1602) or single-
5 wrapped (1604) around the snap hook (1603).

6 6. Sewn stitching (1608, 1624, 1621) or other similar fastening
7 means is used to keep the dielectric and conductive elements
8 of the lanyard capacitor together.

9 In this embodiment of the RF interlock, the lanyard is
10 constructed to be non-conductive to DC current and conductive in
11 an AC sense to RF AC current. Instead of impregnating the
12 lanyard (1601) to make it conductive as in the RF interlock
13 embodiment, this approach permits the operator to be exposed to
14 high voltage levels and still remain electrically isolated from
15 the remainder of the electrical system of the aerialift
16 boom/basket. This is important in some applications where the
17 operator is exposed to high voltage lines such as in power pole
18 maintenance.

19 As to the operation of this particular embodiment, it should
20 be noted that while the lanyard in this configuration is not
21 conductive to DC currents, it can be made highly conductive to AC
22 current at RF frequencies. For example, a lanyard that is two
23 feet long with nylon webbing one inch wide and 0.25 inch thick
24 has the capacitance C (assuming parallel plates on opposing
25 surfaces of the web) given by the relation

1

T03910

$$C = \frac{\epsilon_r \epsilon_0 A}{d}$$

2

where

3

 ϵ_r = relative dielectric constant of nylon

4

 ϵ_0 = dielectric constant of free space (F/m)

5

A = effective capacitor plate area (m²)

6

d = distance between capacitor plates (m)

7 Given the facts above, the effective capacitance of a lanyard

8 capacitor so constructed would be given approximately by

9

T03911

$$C = \frac{(3.1)(8.854 \times 10^{-12})(2 \times 12 \times 1 \times 0.0254^2)}{(0.25 \times 0.0254)}$$

$$\approx 67 \text{ pF}$$

11

See Roger F. Harrington, Time-Harmonic Electromagnetic Fields

12

(ISBN 07-026745-6, 1961), for more information concerning the

13

dielectric constant of various materials. Assuming a RF

14

transmission frequency of 300 MHz, the effective impedance Z of

15

this capacitor is given by the relation

16

T03912

$$|Z| = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

17

$$|Z| = \frac{1}{(2)(3.14)(3 \times 10^8)(67 \times 10^{-12})}$$

18

$$\approx 8\Omega$$

391

1 Thus, the impedance Z of the lanyard capacitor is approximately
2 a short of 8 ohms or so, certainly a much lower impedance than
3 that provided by an open air dielectric between the RF
4 transmitter and the RF receiver connected to the securing D-ring
5 at the aerialift boom/basket.

6 As illustrated in FIGS. 16B and 16C, two preferred
7 embodiments of the capacitive lanyard (1601) are detailed. The
8 first (FIG. 16B) comprises an external conductive element (1612)
9 placed over a lanyard strap and double-wrapped around the snap
10 hook (1609). In this embodiment, two mirror components of this
11 construction are connected together with sewing or other similar
12 fastening means (1624). A gap (1623) exists between the mirror
13 element (1611) and the end of the snap ring to ensure that the
14 secondary conductor (1610) does not short to the first conductor
15 (1613).

16 The embodiment (FIG. 16C) is similar in concept, except it
17 constrains the electrical conductor to be inside the lanyard
18 (1618) so that the conductor (1617) makes contact with the snap
19 hook (1615) when the lanyard is engaged properly. Note that a
20 similar gap (1622) exists in this embodiment to ensure that the
21 two conductors (1620, 1617) do not short together, thus providing
22 dc isolation of the two snap hooks (1602, 1603).

23 One advantage to this particular embodiment is safety in
24 that a higher degree of DC isolation is possible between the

1 aerialift operator and the surrounding aerialift boom/basket
2 electrical system.

3 Thus, this embodiment illustrates how with a slight
4 modification to the safety lanyard a high degree of DC isolation
5 can be maintained between the operator and the aerialift
6 boom/basket electrical system.

7 Another method of implementing the lanyard connection
8 detector (222) (FIG. 2) is illustrated in FIGS. 17A and 17B.
9 Here, the conventional one-piece lanyard (307) of FIG. 3 having
10 two snap hooks (310, 312) connected via a nylon strap or the like
11 is augmented in the following manner:

- 12 1. The configuration of the RF interlock is used, with only a
13 modification to the harness D-ring.
- 14 2. The conventional harness D-ring assembly is reconfigured to
15 include two D-rings (1701, 1703) instead of a single D-ring.
- 16 3. The two harness D-rings (1701, 1703) are constructed so as
17 to have a spring action (1702, 1704) which normally biases
18 the curved ends of each D-ring apart from each other.
- 19 4. The two harness D-rings (1701, 1703) are electrically
20 isolated from each other so as to prevent their electrical
21 contact until and unless their natural spring action (1702,
22 1704) is overcome by an overt operator action thus forcing
23 the curved ends of each D-ring to the opposing D-ring, as
24 illustrated by positions (1705, 1707) and snap clip (1709).

1 5. Electrical contact is made to each harness D-ring so as to
2 affect an electrical contact when the lanyard snap hook
3 (1709) is engaged across both D-rings (1705, 1707) after
4 their natural spring action (1708) has been overcome by an
5 overt operator action.

6 This embodiment specifically addresses the RF transmitter
7 battery life issue presented by the RF interlock embodiment.
8 Normally, the RF transmitter in this application would be
9 activated via the use of a conventional switch or the like. This
10 is problematic in that if the operator forgets to turn off the
11 switch the RF transmitter will operate continuously, thus
12 seriously degrading battery life.

13 A solution to this problem as illustrated in FIG. 18 is to
14 provide a switch to selectively activate the RF transmitter in
15 the body harness only when the operator has positively engaged
16 the safety lanyard snap hook through TWO opposing harness D-rings
17 (illustrated in FIG. 17B) which form the activation circuit for
18 the RF transmitter. Thus, in its normal configuration, with no
19 lanyard attachment, the RF transmitter would be inactive.

20 As illustrated in FIG. 18, this objective is achieved by
21 using the harness D-rings (1803, 1804) as elements of a
22 conductive switch which is made when the harness D-rings are
23 brought together and contacted with the metallic conductor of the
24 lanyard snap hook, thus supplying power from the battery (1802)
25 to the RF transmitter (1801). Additionally, by spring loading

1 the harness D-rings as illustrated in FIG. 17, they remain
2 separated during times in which the lanyard snap hook does not
3 fully engage BOTH D-rings.

4 There are a wide variety of methods to affect the separation
5 of the harness D-rings, including conventional springs, spring
6 steel inserts between the rings, as well as the use of spring
7 steel inserts in the support brackets which restrain the D-rings
8 to the harness.

9 The clear advantage to this implementation of the RF
10 interlock is the potential for long-term battery savings. While
11 the RF interlock is designed to operate a very low transmission
12 levels, it is nonetheless highly desirable to have as long a
13 battery life as possible in this application. Additionally, this
14 configuration provides the feature of prohibiting the operator
15 from circumventing the RF interlock by merely touching the
16 harness D-ring to the support D-ring on the aerialift
17 boom/basket. In this configuration, the contact between the
18 harness D-rings is generated by the lanyard snap hook, meaning
19 that the RF transmitter will ONLY be active when this safety
20 procedure has been properly enforced.

1 Furthermore, this embodiment makes the case for an
2 improvement in body harness design wherein the RF transmitter
3 also detects the proper belting of the body harness around the
4 operator's body as a prerequisite to activation of the RF
5 transmitter.

6 Therefore, the use of a double D-ring within the context of
7 the body harness to promote extended RF transmitter battery life
8 has been demonstrated. This embodiment both promotes battery
9 life as well as providing additional methods of preventing
10 circumvention of the lanyard safety interlock system. While the
11 disadvantage of this system is one of implementation cost, these
12 positive feature improvements may justify the additional cost in
13 some environments.

14 In typical operation, the invention will be configured such
15 that the lanyard interlock will provide sufficient control
16 information to prevent operation of the aerialift boom/basket or
17 the like in the absence of a properly attached safety lanyard.
18 Note, however, that the ability to sense whether the safety
19 lanyard is properly attached permits this information to be used
20 for purposes other than positive safety enforcement as
21 illustrated by the safety monitoring and speech/audible warning
22 feedback system in FIG. 19.

23 Referencing FIG. 19, this system in general is designed to
24 provide both a safety interlock as well as give the operator
25 speech safety messages and log the occurrence of any safety

1 violations during the course of a given day. Safety interlock
2 (1910) can be used as input to a digital latch or other sensing
3 element to detect proper attachment of the safety lanyard (1911).
4 This information, in conjunction with a means for detecting
5 aerialift UP motion requests (1901), can provide information
6 which may be logically ANDed (1912) to provide a trigger to a
7 speech and/or audio warning controller (1902). This controller
8 (1902) issues audio commands to an audio generator (1904), which,
9 in turn, provides audio alarm signals (1906) using speaker (1905)
10 to advise the operator (1907) in the event that that operator
11 (1907) attempts to move the aerialift boom/basket without a
12 proper safety lanyard attachment. This safety protocol violation
13 may also be logged with a date/time stamp into an event memory
14 (1916), which may be later interrogated by safety monitoring
15 personnel or federal regulatory agencies such as OSHA. This
16 information may also be used to provide control to inhibit (1913)
17 the activation of boom movement motors (1915) via a suitable
18 current controller means (1914). Given the wide variety of
19 warning configurations, languages in which the warning messages
20 can be generated, and other system variables, it is envisioned
21 that an alarm selection activator (1903) will be incorporated in
22 this system.

23 Thus, the safety lanyard interlock can form a important
24 piece of a much broader safety management system that is designed

1 to totally manage the safety threats surrounding the use of
2 aerialift boom/baskets and the like.

3 In certain circumstances several of the present invention
4 embodiments can be used in contexts which extend beyond the major
5 application of fall prevention. For example, the RF interlock
6 embodiment of the present invention can be used in conjunction
7 with a safety lanyard to provide positive identification of a
8 given operator to ensure that the operator is properly licensed
9 to operate the machinery, or has been properly trained to use the
10 machinery. This extension of the fall prevention protection
11 envelope can be accomplished in this application because the RF
12 transmission from each safety harness can be made unique via the
13 use of an autoidentification circuit. A similar unique operator
14 identification scheme can be had using the dual lanyard
15 embodiment. Thus, while the present invention and its embodiments
16 permits the enforcement of positive safety procedures regarding
17 elevation devices in general, it may in some circumstances permit
18 the tracking and positive enforcement of other safety policies
19 and procedures outside the narrow scope of fall protection and
20 prevention.

21 FIG 20 shows a flow chart of one method (2000) of providing
22 operator protection according to the teachings of the present
23 invention. The method begins by detecting whether an operator
24 safety lanyard is properly attached to a machinery operator (step
25 2010). Then, unless proper operator safety lanyard attachment is

1 detected, the method inhibits movement of the machinery (step
2 2020). The method (2000) may utilize any of the various
3 embodiments discussed above to accomplish the lanyard attachment
4 detection and movement inhibition steps.

5 The method may optionally include the step of issuing an
6 audible warning to an operator indicating that machinery
7 operation/movement has been inhibited due to a potentially
8 dangerous safety condition (step 2030). In addition or in the
9 alternative, the method may include the step of issuing a visual
10 warning to the operator to indicate that machinery operation has
11 been inhibited due to a potentially dangerous safety condition.
12 (step 2040).

13 Accordingly, a system and method for providing a safety
14 interlock for fall arresting lanyards is disclosed.
15 Significantly, this system takes a positive approach to
16 preventing injury to aerialift boom operators and the like with
17 respect to injuries caused by falls and similar accidents. It
18 should be realized that the present invention may be incorporated
19 into a more widespread aerialift safety threat management system
20 incorporating verbal and/or audible alarms that permit safety
21 feedback information to be given to the operator. In these
22 circumstances, the aerialift operator can be informed of
23 corrective safety measures should he/she attempt to operate the
24 aerialift boom/basket without proper safety lanyard attachment.
25 This type of system is envisioned as being complementary to the

1 present invention, as the present invention permits a wide
2 variety of methods to be applied specifically to the task of
3 determining when the aerialift boom operator is properly secured
4 with a safety lanyard.

5 Modifications and substitutions by one of ordinary skill in
6 the art are considered to be within the scope of the present
7 invention which is not to be limited except by the claims which
8 follow.

9 What is claimed is:

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